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AN ASSESSMENT OF LEARNING DIFFICULTY LEVEL OF MATH CLASS TOPICS - A CASE STUDY OF A JAPANESE PUBLIC JUNIOR HIGH SCHOOL

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ABSTRACT

This work is concerned with the assessment of the difficulty level felt by Japanese junior high school (also called lower secondary school) students towards their mathematics curriculum topics, and the aims are twofold: (1) to understand how these feelings change across school years; (2) to see whether there is any difference in the survey results between male and female students. To accomplish them, a survey assessing the difficulty levels that students feel towards learning curriculum topics was carried out at a typical Japanese public junior high school with 616 students (182 first graders, 212 second graders, and 222 third graders) and located in Niigata Prefecture. A five scale questionnaire was used to evaluate the feelings towards these topics by ranking them as 'has a feeling of being bad at', 'has a feeling of being somewhat bad at', 'neutral', 'has a feeling of being somewhat good at', and 'has a feeling of being good at'. Factor analysis was used to process the data and groups according to the answers were defined and characterized. It was found that factor loadings led to males and females with different number of factors for all grades, which hints to the possibility of the existence of gender dependent feelings towards the learning topics. In addition, the results suggest that the percentage of the group of males defined as 'has a feeling of being bad at multiple modules' increases as they advance in school years whereas female group behaves the other way round. It turns out that these findings help class instructors understand the feelings of difficulty levels that students have to cope with in mathematics classes during the three years of junior high school, which in turn allow class instructors to explore teaching methods focusing also on these issues. In the end, such approaches would possibly influence the student feelings towards mathematical fields in their future studies. Finally, the key point of this investigation is that unlike the general assessments of attitudes towards learning mathematics, this investigation evaluates the anxieties that students feel in relation to specific learning topics of the Japanese junior high school curriculum independent of their performances on academic tests and exams.

KEYWORDS: Mathematics Education, Difficulty Level Assessment & Japanese Junior High School

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Case Study

INTRODUCTION

Background and Literature Review

Roughly speaking, the Japanese educational system consists of 6 years of elementary school education starting at the age of 6 followed by 3 years of lower secondary school (junior high school) and then 3 years of upper secondary school (high school) education, in which the first two make up 9 years of compulsory education (MEXT, 2009). Incidentally, the lower secondary school as known today was established by the school education law as the result of an overall reform in the educational system that that took place after WWII (NIER, 2012).

As far as the characteristics of Japanese education are concerned, Okamoto (2001) grouped them into

three main groups: (i) 'penchant for education' (quoted from the paper) trait of Japanese people, (ii) education as a mean of nurturing personalities and formation of human beings, and (iii) putting 'equality' into practice by means of strict compliance with course of study that guarantee that every single student of the same grade receives the same education at the same time no matter the school location. In fact, taking these for granted, methods aimed at staff development as lesson study has flourished successfully and fruitfully in Japanese school environments (Fernandez, 2008). In mathematics education, in particular, a structured problem solving approach which is centered on the collaborative work of the students to solve the problems on their own prior to teacher's discussion has been adopted in order to stimulate the students' interest in mathematics (Takahashi, 2006; Takahashi, 2016). These and other initiatives have contributed to the achievement of positive results in the international scenario (O'Donoghue, 2014).

Despite all these accomplishments, a great deal of young people have in recent years chosen to pursue careers in fields other than mathematics and science; and the main reason is 'the feeling of being not good at (sense/awareness of having hard time struggling with)' these subjects that students develop over the years (Ishikawa & Sakamoto, 2009). Furthermore, regardless of the high score on objective tests of 'Trends in International Mathematics and Science Study (TIMSS)', scores of subjective questions like 'students like learning mathematics' have fallen short of the international average score (MEXT, 2014). These results raised the question among researchers and educators about whether Japanese students really dislike mathematics and science. In fact, Uchida & Mori (2012) applied Fumie test, which is a kind of implicit association test, on 102 junior high school students in order to make out these issues. Briefly, their results showed that females overcome males in terms of dislike feelings towards mathematics and science even though they had kind of sympathy for these disciplines.

It is worth noting here that, on a grand scale, gender gap seen in academic performance have been an object of study even in the scope of TIMSS, and the findings so far indicates that the differences are due to a variety of social and cultural factors (Guiso et al., 2014; Nollenberger et al., 2014). Apropos, these components have appeared quite frequently these days in discussions about the score gap between Western and Asian countries (Geary, 1996; Leung et al., 2006; Md-Yunus, 2010; Jerrim, 2014). In fact, it has been pointed out that these elements translate essentially into high expectation for success that not only the family but also the society put on the students (Breitenstein, 2013), and entrance examination pressure that students face in every stage of their studies as well (Hirabayashi, 2006).

Taking these into account and motivated by the available literature, the goal of this work is to assess the difficulty level felt by Japanese junior high school students towards their mathematics curriculum topics in order to figure out how these feelings change across school years as well as whether there is any gender gap.

Finally, it is worth pointing out that further results of our research project can be found elsewhere (Izuta & Nishikawa, 2016; Nishikawa & Izuta, 2016).

METHODS

Respondents

A public junior high school located in Niigata Prefecture was chosen to perform the case study. The total number of students was 616 students, in which 182 were first graders, 212 second graders, and 222 third graders. The students were all in the age range of 12 to 15 years old, and male-female ratio was about fifty-fifty.

Survey

A five scale questionnaire ranging from 'has a feeling of being bad at', 'has a feeling of being somewhat bad at', 'neutral', 'has a feeling of being somewhat good at', and 'has a feeling of being good at' was designed to evaluate the feelings and anxiety towards learning topics.

Data Processing

The data processing was carried out on a computer with Window 8 platform and running the Microsoft Excel 2013 application. Factor analysis was used to analyze the data as well as define and characterize the groups of respondents. As matter of fact, this analysis was performed with an Excel add in, which is widely used in Japan (Kikuchi, 2016)

RESULTS

The results of first, second and third graders are presented in this order hereafter. Moreover, the males and females are displayed separately in order to examine for the gender gap, and the definitions of the factor groups are all adjusted to allow comparisons between them.

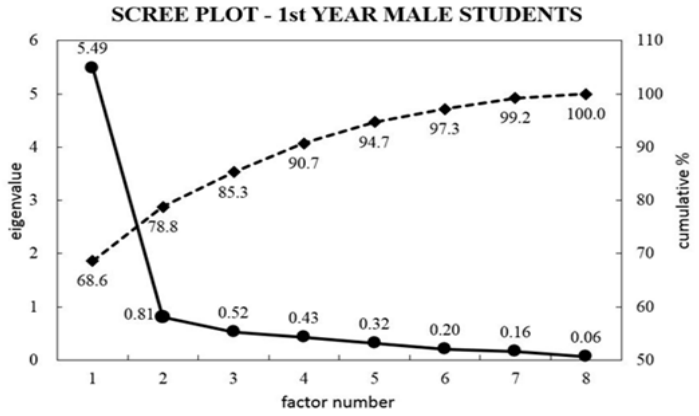

Figure 1: Scree and Cumulative Percentage - 1st Year Males

Table 1: Definition of Factors - 1st Year Males

1st year male student factors according to FA loadings

		Factor 1	Factor 2	Factor 3
		has a feeling of being bad at algebra	has a feeling of being bad at geometry and histogram	has a feeling of being bad at proportionality
Q1	positive and negative numbers	**-0.736**	-0.401	-0.266
Q2	algebraic expresssions using letters	**-0.878**	-0.287	-0.364
Q3	linear equation with one unkown	**-0.680**	-0.286	-0.424
Q4	plane figures	-0.226	**-0.822**	-0.177
Q5	spacial figures	-0.339	**-0.775**	-0.307
Q8	histograma and representative data	-0.368	**-0.450**	-0.358
Q6	direct proportion, equation and graph	-0.492	-0.249	**-0.698**
Q7	inverse proportion, equation and graph	-0.291	-0.302	**-0.785**

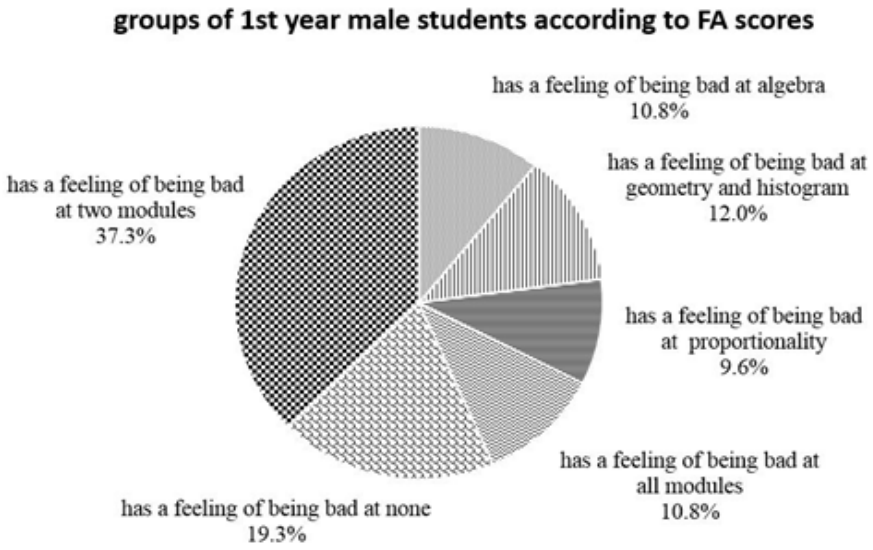

Figure 2: Characterization of 1st Year Male Students

Figure 1 shows the scree and cumulative percentage plots for 1st year male students. Considering a decrease of 0.15 between the factor numbers and the cumulative percentage around 70% as references to define the point of inflexion on the scree curve, the number of factors reads 3. These three factors and the loadings computed during the factor analysis allows us to gather the questionnaires of the survey in groups as shown in Table 1. Now, focusing on the scores of the respondents, they can be categorized as depicted in Figure 2. The number of students who have that feeling of being bad at none of the study modules is about one fifth (19.3%) of the total, which means that 80.7% of the students have either some kind of weakness feelings or anxieties towards learning mathematics. Yet, the number of students who struggle with all of the learning topics amounts to 10.8% of the respondents, which added to those who find it difficult to learn two modules account for about half of the respondents.

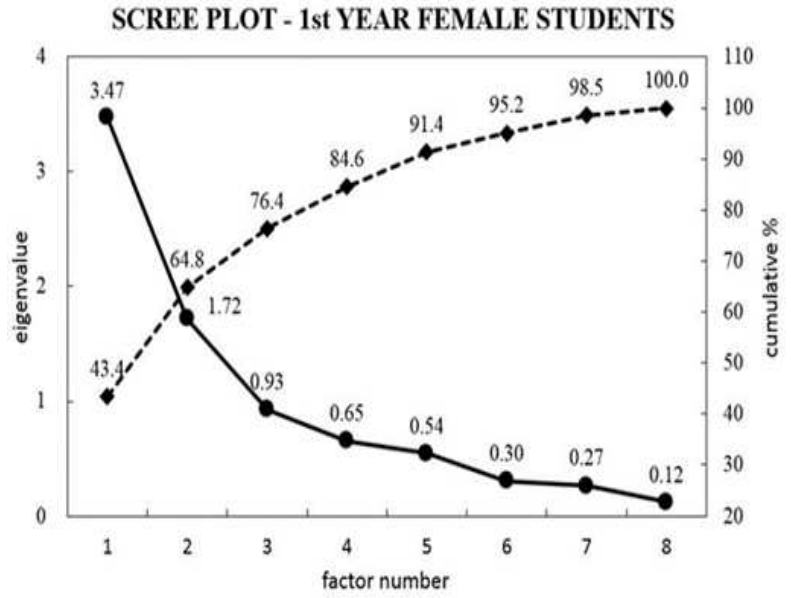

Figure 3: Scree and Cumulative Percentage - 1st Year Females

Table 2: Definition of Factors - 1st Year Females

1st year female student factors according to FA loadings

		Factor 1	Factor 2	Factor 3	Factor 4
		has a feeling of being bad at algebra	has a feeling of being good at proportionality and histogram	has a feeling of being bad at geometric construction	has a feeling of being good at areas and volumes
Q1	positive and negative numbers	**-0.762**	0.067	-0.160	0.270
Q2	algebraic expresssions using letters	**-0.953**	0.084	-0.111	0.029
Q3	linear equation with one unkown	**-0.891**	0.157	-0.069	0.082
Q6	direct proportion, equation and graph	**-0.083**	0.910	-0.127	0.019
Q7	inverse proportion, equation and graph	-0.156	**0.724**	-0.055	0.178
Q8	histograma and representative data	-0.025	**0.438**	-0.314	0.208
Q4	plane figures	-0.208	0.184	**-0.828**	0.178
Q5	spacial figures	-0.209	0.224	-0.212	**0.774**

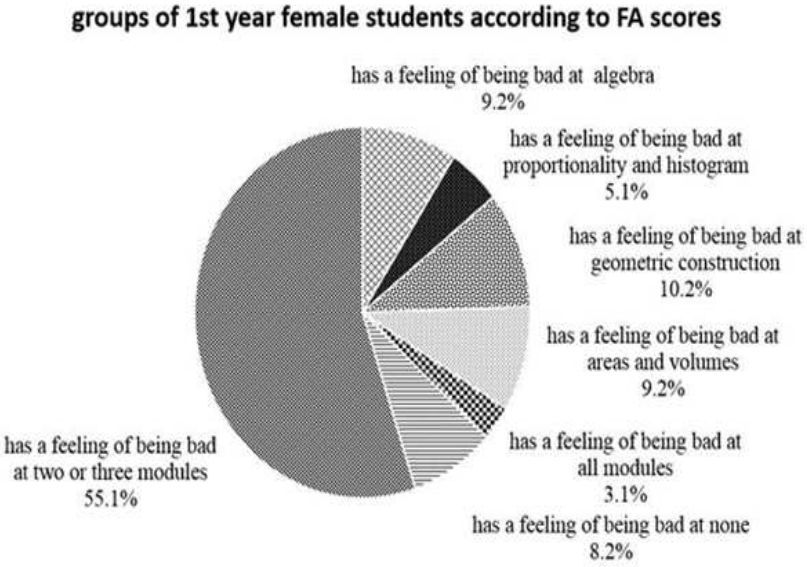

Figure 4: Characterization of 1st Year Female Students

Unlike the male counterparts, first year female students had the number of factors set to 4, which corresponds to a cumulative percentage at 84.6% as portrayed in Figure 3. Table 2 shows that the definitions of these factors. Nevertheless two factors were defined as related to ‘a feeling of being good at’ whereas the other two meant ‘a feeling of being bad at’ as given in Table 2, the groups of students worked out from the scores were such that the group ‘feeling of being bad at all modules’ amounted to 3.1% and ‘feeling of being bad at two or three modules’ to 55.1%, which sum up to 58.2% of the respondents as easily read out of Figure 4. In addition, the percentage of female students in the group labelled ‘has a feeling of being bad at none’ is only 8.2%. It is worth noting that the former is a little over 10% higher whereas the latter is more than 10% lower than the figures obtained previously for first year male students. These suggest that there is a gender dependent anxiety towards mathematics education in the very first year of junior high school.

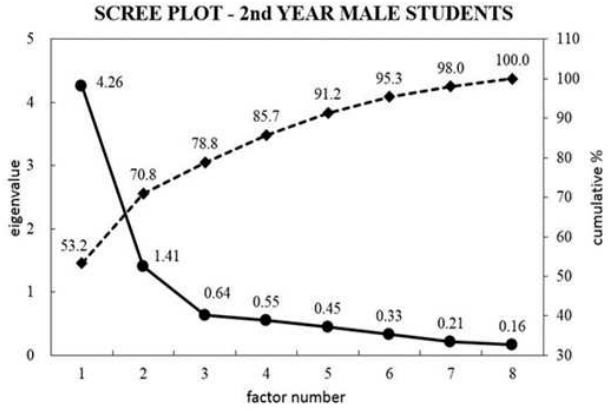

Figure 5: Scree and Cumulative Percentage - 2nd Year Males

Table 3: Definition of Factors - 2nd Year Males

2nd year male student factors according to FA loadings

		Factor 1	Factor 2	Factor 3
		has a feeling of being good at geometry	has a feeling of being bad at polynomial and simultaneous equation	has a feeling of being good at linear function
Q4	plane figures	**0.800**	-0.293	-0.007
Q5	congruence of plane figures	**0.726**	-0.117	0.089
Q6	properties of triangles and parallelograms	**0.875**	-0.111	0.359
Q1	polynomials	0.185	**-0.717**	0.230
Q2	algebraic expresssions using letters	0.175	**-0.552**	0.357
Q3	simultaneous linear equations	0.195	**-0.758**	0.185
Q7	linear functions	0.186	-0.409	**0.702**
Q8	probability	0.324	-0.357	0.282

groups of 2nd year male students according to FA scores

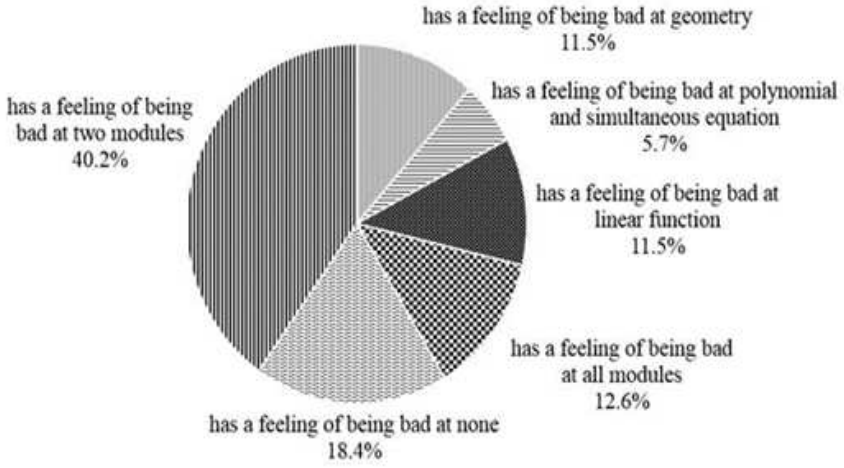

Figure 6: Characterization of 2nd Year Male Students

As far as the second year students are concerned, the scree and cumulative percentage plots for second year males are pictured in Figure 5. Here, the number of factors was based on the hitherto criteria chosen to be 3, which corresponds to a cumulative percentage of 78.8%. It turns out that Factors 1 and 2 were related to groups defined by 'has a feeling of being good at geometry' and 'has a feeling of being good at linear function' respectively as tabled in Table 3. These factors in turn lead to the groupings of students as exhibited in Figure 6. The group marked 'has a feeling of being bad at none' comprised 18.4% of the respondents whereas the group 'has a feeling of being bad at all modules' stood for 12.6%. On considering that the group 'has a feeling of being bad at two modules' added up to 40.2% of the respondents, the percentage of second year students having issues with two or all of the modules reaches up to a value a little over the half of the respondents, namely 52.8% of them in all.

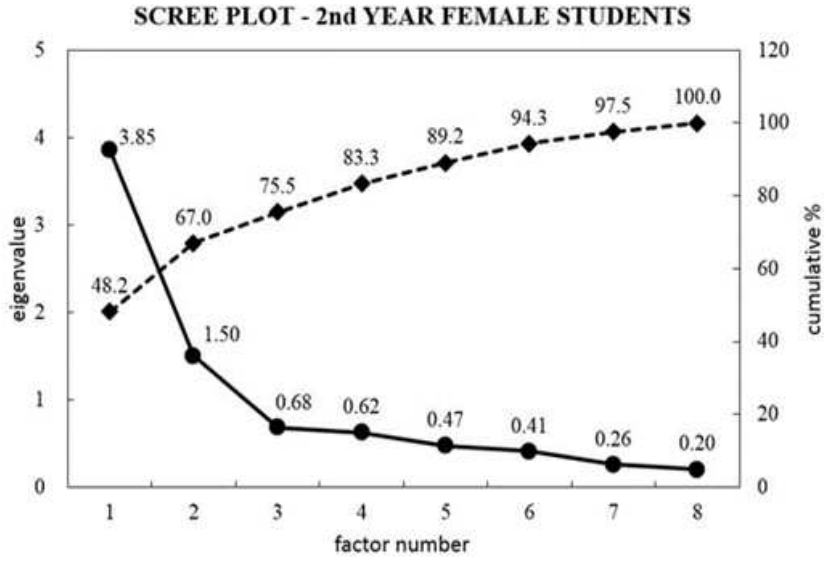

Figure 7: Scree and Cumulative Percentage - 2nd Year Females

Table 4: Definition of Factors - 2nd Year Females

2nd year female student factors according to FA loadings

		Factor 1	Factor 2	Factor 3
		has a feeling of being good at geometry	has a feeling of being bad at polynomial and simultaneous equation	has a feeling of being good at linear function
Q4	plane figures	**0.682**	-0.170	-0.012
Q5	congruence of plane figures	**0.825**	-0.194	0.137
Q6	properties of triangles and parallelograms	**0.849**	-0.092	0.179
Q1	polynomials	0.140	**-0.971**	0.190
Q2	algebraic expresssions using letters	0.211	**-0.557**	0.440
Q3	simultaneous linear equations	0.156	**-0.590**	0.316
Q7	linear functions	0.138	-0.324	**0.809**
Q8	probability	0.371	-0.387	0.248

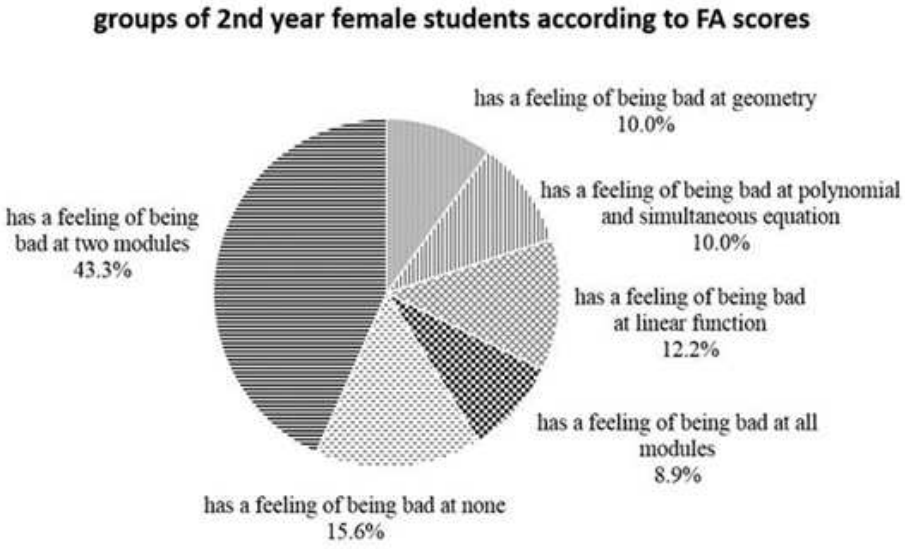

Figure 8: Characterization of 2nd Year Female Students

As for the second year female students, the scree and cumulative percentage plots illustrated in Figure 7 shows that it is reasonable to take the number of factors to be 3 as done in this work. Moreover, note that the cumulative percentage took the value of 75.5%. As a result, the factors are interpreted as 'has a feeling of being good at geometry', 'has a feeling of being bad at polynomial and simultaneous equation', and 'has a feeling of being good at linear function' as represented in Table 4. Now, Figure 8 shows that the group 'has a feeling of being bad at none' gathered 15.6% of the 2nd year female respondents. As a matter of fact, comparing with the same group of males, it is easy to see that the difference is a little less than 3%. On the other hand, the groups 'has a feeling of being bad at all modules' and 'has a feeling of being bad at two modules' sum up to 52.2%, which is very similar to the value obtained for male peers. Note also that the figures turned around relatively to first year students.

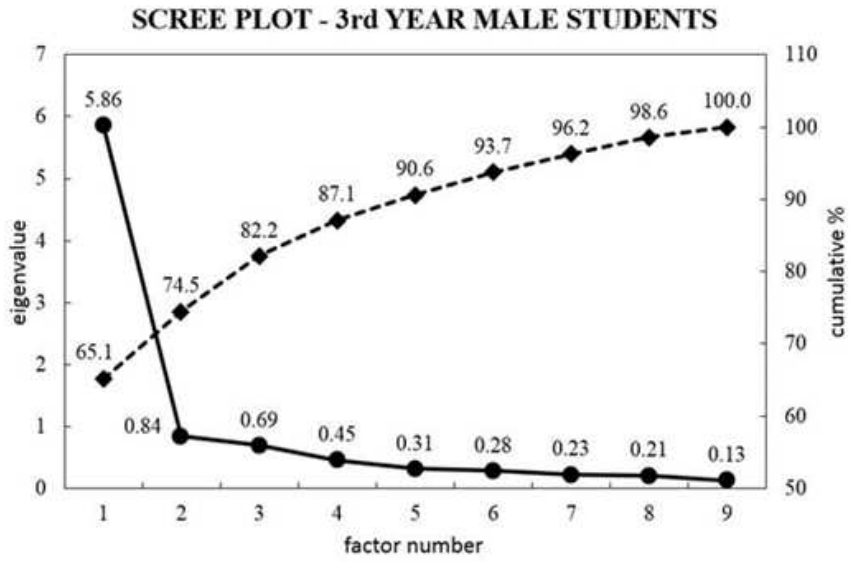

Figure 9: Scree and Cumulative Percentage - 3rd Year Males

Table 5: Definition of Factors - 3rd Year Males

3rd year male student factors according to FA loadings

		Factor 1	Factor 2	Factor 3	Factor 4
		has a feeling of being bad at algebra	has a feeling of being good at geometry	has a feeling of being good at data analysis	has a feeling of being good at quadratic function
Q1	expansion of expressions	**-0.738**	0.361	0.293	0.067
Q2	factorization of expressions	**-0.735**	0.193	0.473	0.144
Q3	quadratic equations	**-0.782**	0.235	0.233	0.304
Q4	solving quadratic equations	**-0.758**	0.341	0.114	0.402
Q5	similarity of plane figures	-0.243	**0.825**	0.215	0.203
Q6	inscribed angle and central angle	-0.306	**0.602**	0.447	0.240
Q7	Pythagorean theorem	-0.470	**0.564**	0.266	0.263
Q9	sample survey	-0.267	0.277	**0.663**	0.127
Q8	function $y=ax^2$	-0.357	0.417	0.208	**0.623**

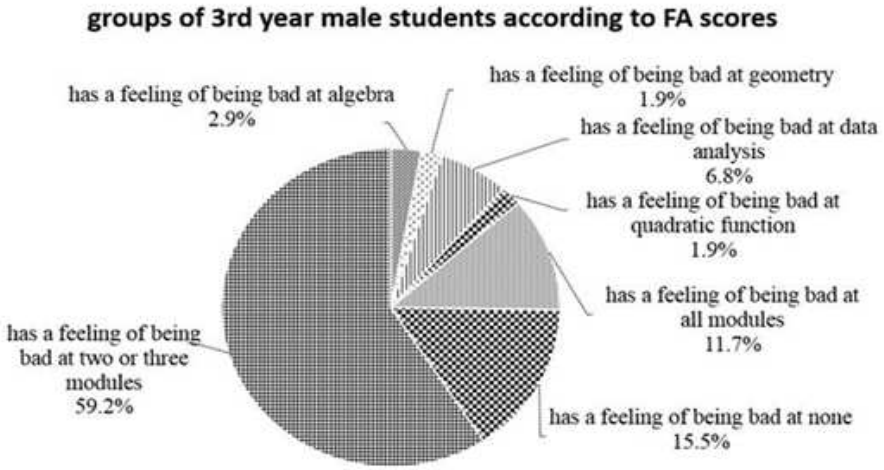

Figure 10: Characterization of 3rd Year Male Students

Figure 9 shows the scree and cumulative percentage for third year male students. Here, in spite of the point of inflexion at factor number 2, the one at 4 is adopted to classify the items of the questionnaire. In fact, these four factors made up the groups defined as ‘has a feeling of being bad at algebra’, ‘has a feeling of being good at geometry’, ‘has a feeling of being good at data analysis’, and ‘has a feeling of being good at quadratic function’ as described in Table 5. On taking the scores of each student and gathering them according to the definitions of factors, Figure 10 shows that the share of ‘has a feeling of being bad at none’ accounted for 15.5% of the respondents. Furthermore, ‘has a feeling of being bad at all modules’ had 11.7%, and ‘has a feeling of being bad at two or three modules’ totted up 59.2%, which summed up to 70.9% of third year male respondents. As discussed later on, the numbers related to ‘being bad at multiple modules’ increased for males as the school years advanced.

Table 6

3rd year male student factors according to FA loadings

		Factor 1	Factor 2	Factor 3	Factor 4
		has a feeling of being bad at algebra	has a feeling of being good at geometry	has a feeling of being good at data analysis	has a feeling of being good at quadratic function
Q1	expansion formula	**-0.738**	0.361	0.293	0.067
Q2	factorization	**-0.735**	0.193	0.473	0.144
Q3	algebra of square root numbers	**-0.782**	0.235	0.233	0.304
Q4	quadratic equations	**-0.758**	0.341	0.114	0.402
Q5	congruence of triangles	-0.243	**0.825**	0.215	0.203
Q6	central angles and arcs	-0.306	**0.602**	0.447	0.240
Q7	pythagorean theorem	-0.470	**0.564**	0.266	0.263
Q9	data analysis	-0.267	0.277	**0.663**	0.127
Q8	function y=ax2	-0.357	0.417	0.208	**0.623**

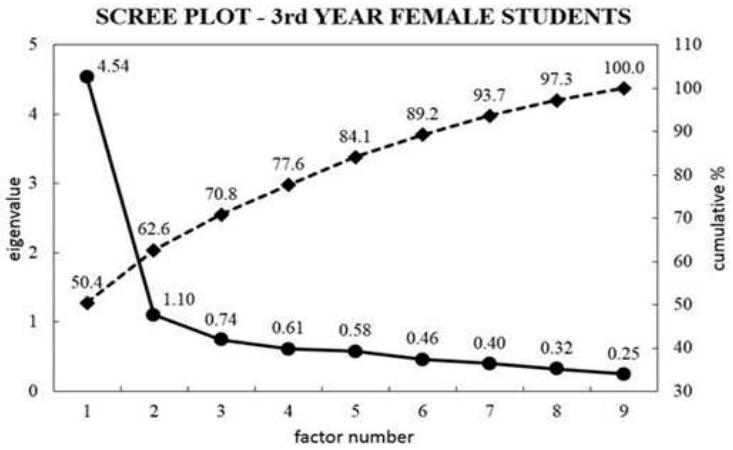

Figure 11: Scree and Cumulative Percentage - 3rd Year Females

Table 7: Definition of Factors - 3rd Year Females

3rd year female student factors according to FA loadings

		Factor 1	Factor 2	Factor 3
		has a feeling of being good at geometry and data analysis	has a feeling of being bad at algebra	has a feeling of being good at quadratic function
Q5	similarity of plane figures	**0.669**	-0.161	0.223
Q6	inscribed angle and central angle	**0.638**	-0.323	0.119
Q7	Pythagorean theorem	**0.638**	-0.242	0.059
Q9	sample survey	**0.561**	-0.140	0.144
Q1	expansion of expressions	0.341	**-0.579**	0.137
Q2	factorization of expressions	0.161	**-0.826**	0.273
Q3	quadratic equations	0.321	**-0.633**	0.024
Q4	solving quadratic equations	0.213	**-0.484**	0.310
Q8	function $y=ax^2$	0.312	-0.263	**0.900**

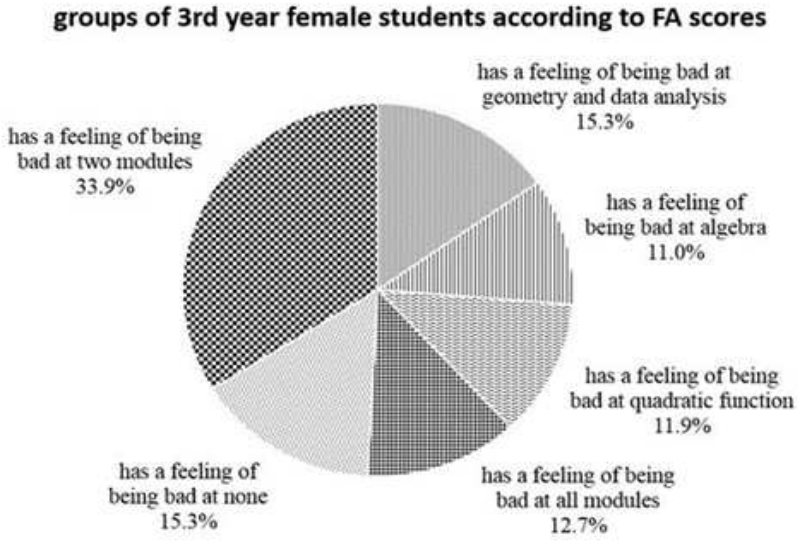

Figure 12: Characterization of 3rd Year Female Students

Finally, the scree and cumulative percentage graphs of third year female students given in Figure 11 provides three factors to explain 70.8% of the data variances. Consequently, three groups are figured out from the loadings, namely 'has a feeling of being good at geometry and data analysis', 'has a feeling of being bad at algebra', and 'has a feeling of being good at quadratic function' as described in Table 7. Now, Figure 12 comes out from grouping the respondents on the basis of their scores, in which 'has a feeling of being bad at none' stands for 15.3%, a figure pretty similar to the one seen in the third year male case as well as in second year female respondent analysis. In addition, 'has a feeling of being bad at all modules' marked 12.7%, which is 1% higher than male peers. Adding this value to 33.9% of 'has a feeling of being bad at two modules' leads to 46.6%, which is far lower than the third year males' 'has a feeling of being bad at multiple modules'.

DISCUSSIONS

The results showed that 'has a feeling of being bad at none' shrinks from 19.3% (grade 1) to 18.4% (grade 2) down to 15.5% (grade) for males whereas for the females the figures read 8.2% (grade 1), 15.6% (grade 2) and 15.3% (grade 3). Nevertheless the initial values of males and females are pretty different and change across the grades having contrasting patterns, their final percentages are similar to each other. Restricting to the female case and considering the social expectations that students carry on their shoulders (Breitenstein, 2013), it is conceivable that this improvement in the numbers has something to do with the high school (upper secondary school) entrance examination that students undergo at the end of third grade, and cram schools that many students attend as supplementary education (Dierkes, 2011), which reteaches over and over the materials taught in schools and they are, on their own rights as businesses, highly exam-oriented as pointed out by Pettersen (1993).

With regard to the group 'has a feeling of being bad at all modules', the numbers were 10.8% (grade 1), 12.6% (grade 2), and 11.7% (grade 3) for males, which showed relatively a small fluctuation around 12%. On the other hand, females hiked from 3.1% (grade 1) up to 8.9% (grade 2) to then reach 12.7% (grade 3), which suggests that at the end of junior high school, both males and females are approximately at the same level. Yet, these values are lower than those previously seen in 'has a feeling of being bad at none'.

Now focusing on the group 'has a feeling of being bad at two or more modules (learning topics)', males began with 48.2% (grade 1), then boosted from 52.8% (grade 2) to 70.9% (grade 3) whereas females showed a decreasing pattern beginning at 58.2% (grade 1) then decreasing slightly to 52.2% (grade 2) and going down to 46.6% (grade 3). These ciphers suggests that as far as the feelings (regardless of academic performances) of being 'good at' and 'bad at' are concerned, it is likely that males have to deal with their learning anxieties more often than their female counterparts; and on recalling that, in Japan, careers in mathematics and science are pursued mainly by males, this struggling period is relatively longer. In either case, the results indicate that a very significant portion of students carry over some kind of anxiety feelings in math classes.

CONCLUSIONS

As in the long run these feelings have a huge impact on students as well as the society as a whole (Geist, 2010), development of teaching and class management methods taking into account the students' awareness of their own state of mind with respect to each specific learning topic would be a way to help them bear up the psychological burden, and would presumably contribute to the increase in the numbers of 'students like learning mathematics'.

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